# Manual for the Nile-Goblet open-source GIS tool

## Drawing your own suitability maps for rainwater management strategies made easy

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# How to use this training manual

This manual has a twofold objective:

(i) to teach the basic manipulations of the Nile-Goblet tool, and
(ii) to enable participants to create their own maps based on their own knowledge of rainwater management.

Because human beings tend to learn better when they have to discover how things work by themselves, the training mainly works with exercises that lead the participant through the different manipulations of the Nile-Goblet tool without first showing how to perform them.

The manual can be used for self-study or as a manual during instructor-led training. The manual has three distinctive parts. The first part is theoretical and aims at explaining basic concepts of rainwater management upon which the tool is based. Within instructor-led training, this part can presented during the training in traditional classroom settings. The second part shows the basic features of the Nile tool and is accessible to anyone even without any prior GIS background. It discusses in detail the different manipulations in the tool as well as the different options. Participants have to discover this part of the manual on their own by trying to solve the exercises.

> *Exercises for the Nile Goblet tool are always presented in a text box. The manipulations needed to solve the exercise are explained in the manipulation part above the box.*

In an instructor-led training, participants who face challenges to solve the exercises can be supported by trainers. They can explain in a personal and individualized way the concepts or manipulations that are not well understood. This approach allows each participant to learn in her/his own way and own pace. Every 2 hours, the exercises have to be discussed in plenary so that trainers ensure that all the participants have truly understood the challenges of the exercise. For self-study, the solutions to the exercises are placed at the end of the manual, to allow getting the major learning points of each exercise.

The third part of the manual focuses on how to populate the Nile Goblet tool with new data and is meant for people with background in GIS. This part shows how to transform existing data layers that are not in the right format, so that they can be introduced into the tool. This requires basic GIS background about data management and projection, as well as a basic GIS software. In this manual we present the necessary manipulation for both the ArcGIS and Grass software packages. Grass isan open source GIS software with an user interface that allows for data conversion. A separate section contains exercises that can be solved both in ArcGIS and Grass.

Preparing your own geographical layers from collected data is beyond the purpose of this manual. We suggest using the *GIS training for agricultural research centers*[1] developed by Nile Basin Challenge Program (NBDC) and the Amhara Regional Agricultural Research Institute (ARARI) to learn how to collect your own data and create geographical layers from those.

[1] Downloadable from https://docs.google.com/folder/d/0B_BdeBrudKuyVEEtdFBGZjZFWEk/edit

# Table of Contents

# 1 Introduction

The Geographic Overlaying data Base and query Library for Ex-anTe impact assesment (GOBLET) is a decision support system module that facilitates the screening of spatial domains and therefore the development of better targeted agricultural options, i.e., introducing technologies and/or management practices. It can also serve as a core library for the production of customized geographic information systems (Quiros et al., 2009). It does not require any prior Geographical Information System (GIS) knowledge.

The Nile-Goblet tool is based on this original code, but has been adapted to the specific need for mapping rainwater management strategies in the Ethiopian Blue Nile basin. Whereas the original tool could perform only simple suitability maps based on bio-physical criteria, the new version allows the introduction of socioeconomic constraints through the so-called “willingness of adoption map”, as well as the aggregation of different rainwater management practices to the landscape (watershed) scale.

# 2 Mapping rainwater management strategies at landscape scale

## 2.1 Theoretical concepts to rainwater management

The Nile-Goblet tool is based on theoretical concepts of rainwater management developed within the NBDC project.

### 2.1.1 Rainwater management practice (RMP)

Rainwater management practices (RMPs) are understood as any water management technology or practice which can be adopted by a smallholder on his plots or farm. As such RMPs refer to a broad range of practices. Beyond traditional water related technologies, it encompasses practices related to crop, livestock and trees which contribute to water availability or water productivity on the smallholder’s own plot, i.e. the farm scale or increase the water availability or productivity on other plots within the watershed, i.e. the landscape scale (De Fraiture et al., 2010). Example of RMPs are terraces, bunds, planting fruit trees, planting multipurpose trees, wells, pumps, river diversions, water harvesting ponds, soil fertility management, check dams and conservation agriculture. Desta et al. (2005) gives a good overview of possible rainwater management practices in Ethiopia.

### 2.1.2 Rainwater management strategies (RMS)

Implementing single rainwater management practices might not lead to the expected overall benefits but need to be implemented in combination with other practices. In addition, some practices might have positive or negative impacts on downstream farmers. In order to take these synergies or trade-offs into account, rainwater management should be optimized at landscape scale rather than at farm scale.

In terms of rainwater management, the landscape approach suggests focusing on a watershed that contains a variety of land uses on a top slope (upland), a middle slope (midland) and the bottom valley (lowland) and is managed by its inhabitants. A rainwater management strategy (RMS) can then be

understood as a combination of rainwater management practices that cover the whole slope gradient of the landscape and that optimize water availability or water productivity of the whole watershed. From this perspective, the landscape approach implies that the synergies between different practices within the landscape are considered to be the same in all the landscapes modeled.

Different objectives need to be met by the different RMPs in each of the landscape zones. By maximizing the potential synergies and minimizing negative trade-offs between these individual RMPs the aim is then to optimize the multiple objectives at the landscape scale. This rationale is used for coming up with site-specific strategies. Table 1 shows examples of RMPs in each zone with their specific objectives. Combinations of these RMPs then form RMSs with an overarching goal of increasing the overall water productivity or water availability in the watershed.

**Table 1 : objectives of different land uses in each landscape zone with examples of RMPs in italic**

<table>
<tr><th rowspan="2">Zone\Land use</th><th colspan="3">Main objective (examples)</th></tr>
<tr><th>Cropland</th><th>Grassland</th><th>Degraded land</th></tr>
<tr><td>Uplands</td><td>Increase infiltration<br>Agro-forestry, forestry</td><td rowspan="3">Increase the quantity and quality of fodder for livestock<br>over-sowing, limiting animal movement</td><td rowspan="3">Rehabilitate degraded land<br>half-moon, forestry</td></tr>
<tr><td>Midlands</td><td>Control erosion, maintain soil moisture<br>Soil and water conservation<br>Agro-forestry<br>Conservation agriculture</td></tr>
<tr><td>Lowlands</td><td>More efficient use of surface or shallow water<br>Wells, river diversion</td></tr>
</table>

In the upland the objective is mainly to increase water infiltration through, for example, agroforestry and forestry. The midland is usually relatively hilly and practices should therefore aim at controlling erosion and maintaining soil moisture through in-situ soil and water conservation, or through conservation agriculture or agro-forestry. In the lowlands water is usually available in the form of groundwater or as a river. The objective in this zone is to increase the productivity of surface and shallow water. Rainwater management in the grassland as well as heavily degraded land has particular objectives regardless of the landscape zone. On grassland, fodder quantity and quality need to be improved, whereas on heavily degraded land, rehabilitation is the major objective. Finally, fertility management and ex-situ rainwater harvesting can potentially be applied everywhere regardless of the bio-physical conditions and therefore are not retained in this mapping exercise. This does not imply that they are not important in rainwater management but they can be combined with any other RMP.

## 2.2 Bio-physical suitability maps in Goblet

Every RMPs has its own suitability range based on a number of bio-physical criteria. Creating bio-physical suitability maps implies combining geographic layers (geographical data) for each of these criteria and looking for locations where the suitability range for each of them is met. A geographical overlay needs to be performed in order to identify locations where a given practice is suitable. Different steps are needed to compute these suitability maps. They are shown in **Figure 1**. A straight line box in the figures suggests a given step requires user input, whereas a broken line box suggests that this given step is automatically performed in Goblet.

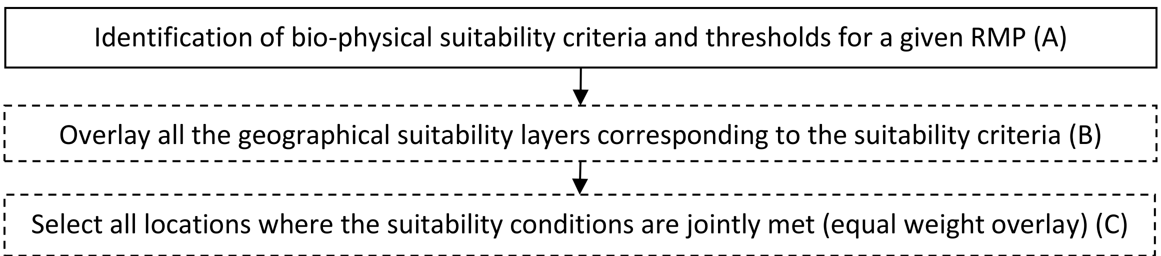



**Figure 1 : mapping approach for single suitability maps (in straight lines, user input needed for Goblet, and broken line for steps automatically computed in Goblet)**

In a first step, for any given RMP bio-physical suitability conditions need to be identified (A). Only those conditions for which a geographical layer exists can be included. Nile Goblet contains a wide variety of available layers for the Ethiopian Blue Nile basin from which one can choose. Thresholds for suitability can be defined by the user of the Nile-Goblet tool although the tool suggests thresholds based on literature review and expert knowledge.

Goblet overlays all the selected geographical layer (B) and selects all locations which fit the suitability range selected in A. It makes use of equal weight aggregation technique to do so.

These suitability maps are by construction a binary map that indicates locations where all bio-physical conditions are met.

## 2.3 Introducing socio-economic constraints into goblet: feasibility maps

Introducing socio-economic and institutional characteristics into Goblet in the same way than bio-physical criteria is in principle possible. But many socio-economic studies contradict themselves and consequently defining clear suitability ranges or weights for aggregation into a single suitability map is difficult.

The Nile-Goblet tool uses “willingness of adoption” maps as an alternative approach to introduce the socio-economic constraints. These maps predict potential adoption at woreda (district) level and suggest which percentage of the farming households within that woreda is likely to adopt a given RMP.

“Willingness of adoption maps” are constructed with the so-called small area estimation technique, a technique that is usually applied to income model in order to assess poverty (Davis, 2003; Hyman et al.,

2005). In most simple words, it extrapolates results from a linear econometric model based on a farm household survey to broader scales by predicting the model with full coverage census data.

For the Nile-Goblet tool six willingness-of-adoption maps have been prepared: (i) for soil and water conservation, (ii) for irrigation from the river, (iii) for orchards, (iv) for multipurpose trees, (v) for wells and (vi) for water harvesting.

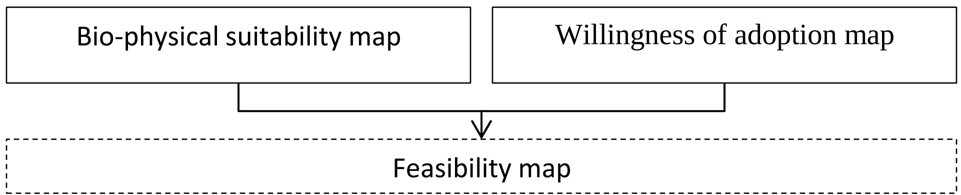



**Figure 2 : procedure to get the feasibility maps (in straight line user-input need for Nile-Goblet)**

A feasibility map is the overlay between the bio-physical suitability map (by construction a 0/1 map constructed in the previous step) and the willingness of adoption map (by construction a 0-1 map). It shows the percentage of adoption of a given RMP in the suitable locations.

The willingness-of-adoption maps have been computed for a whole category of RMPs. Consequently, one willingness-of-adoption map can be combined with different RMPs suitability maps. For example, terraces, bunds and gully rehabilitation are 3 different RMPs for which Goblet constructs separate biophysical suitability maps, but they will all three make use of the willingness-of-adoption map for soil and water conservation to compute the feasibility map.

## 2.4 Up-scaling to the landscape scale

Up to this point results from the tool are suitability and feasibility maps for single RMPs. Up-scaling, that is aggregating the suitability and feasibility map into a landscape/watershed scale is needed. The up-scaling procedure is presented in Figure 3. The single feasibility maps resulting from the previous step are combined with a landscape layer (A), a shape file that represents the landscape/watershed, to compute a zonal statistics. The zonal statistics return statistical information for each of the landscapes/watersheds, namely the percentage of the area that is suitable based on the suitability maps as well as the average adoption rate on suitable location based on the feasibility maps.

In addition to looking at whole landscapes or watersheds, different practices are combined into strategies. For this strategies need to be quantified. For suitability maps this is done by defining a minimal area threshold to be fulfilled for each practice forming the strategy. For feasibility maps, the minimal percentage of adoption on suitable locations of the practices that form the strategy will be retained as adoption rate at watershed level.

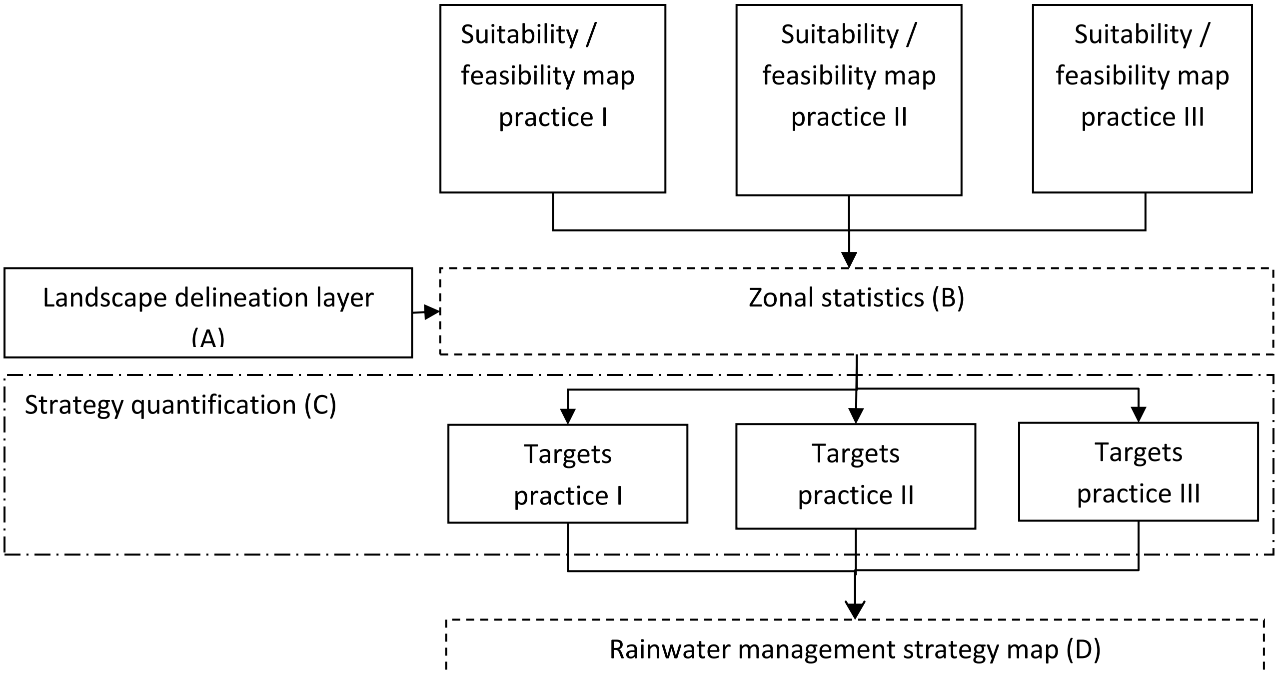



**Figure 3 : the up-scaling procedure in Goblet (in straight lines user-input for the Nile Goblet)**

# 3 Basics of the Nile-Goblet tool

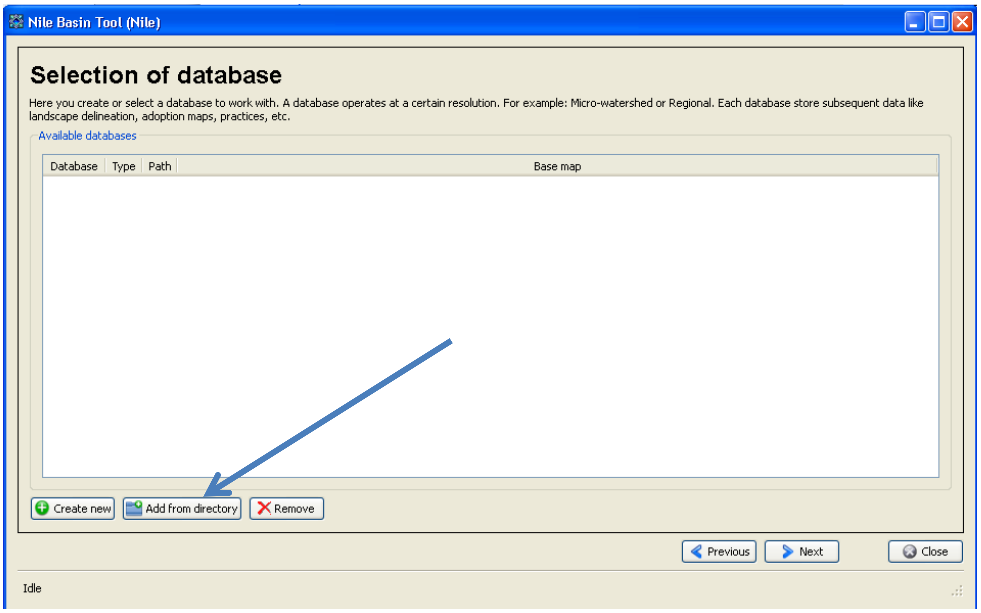
## 3.1 How to install the program

The Nile-Goblet tool consists of two modules: Goblet, the base code and the Nile code which includes the aggregation to the landscape. You need to install Goblet first and then the Nile tool. You can install them by double clicking on the executable files: (i) GOBLET-setup.exe and (ii) Nile-setup.exe. The installation wizard takes you through the step-by-step installation process.

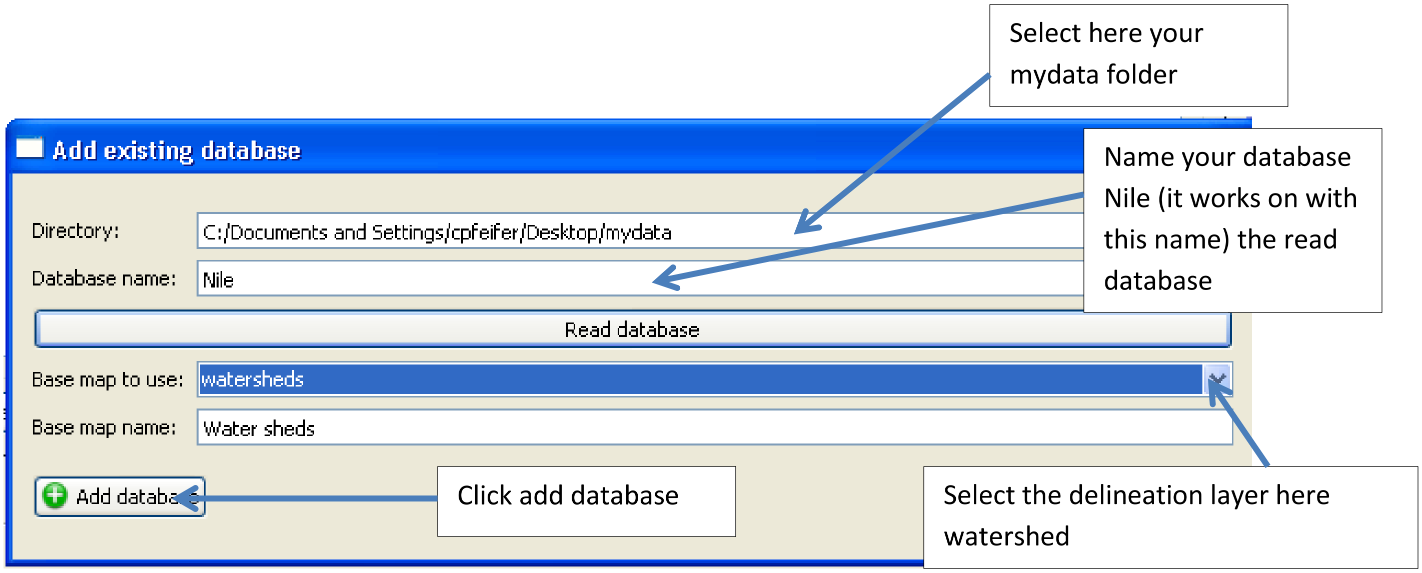
This installation results in an empty toolbox, with all functionalities working but no data. The most common datasets, practices and strategies have already been prepared for the Blue Nile, and are available in the mydata zip file. You can download the data zip file and extract it.

*To open the Nile-Goblet tool, use start button-all programs-Nile basin tool*

*To load existing database, click adding from directory*




*Then add the mydata folder, name the database Nile and read the database. From this database you can select a base map that defines the extend of the basin and is watershed.*



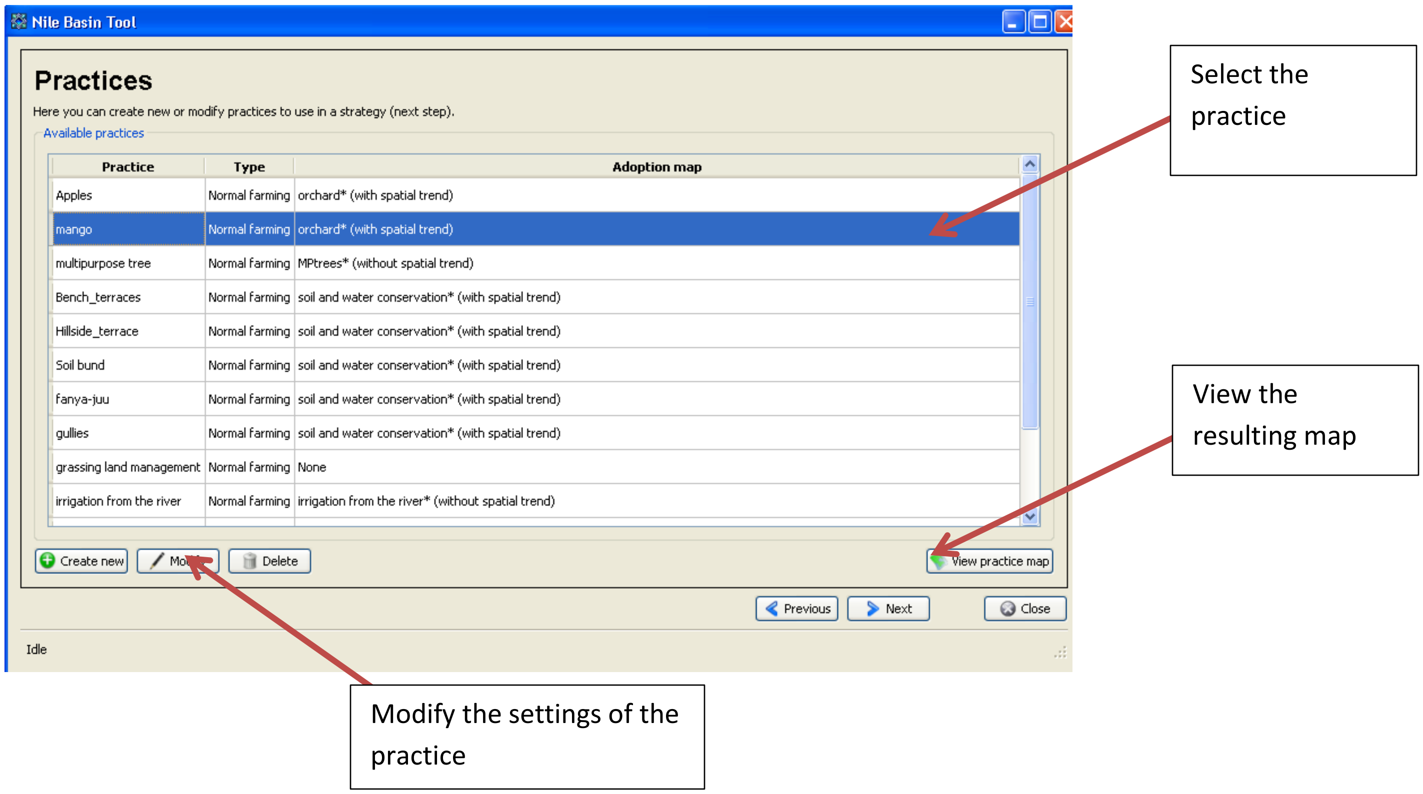

You can also create your own database and choose its resolution (between 10 km, 1km and 10m resolution) and extend delineate by a "base map" of your choice. This allows you to use the Nile tool for any region of the world or to model a micro-watershed. Note that if you use a 10 m, your base map should represent a micro watershed up to 30 squared km. If your base map is bigger, your computer is unlikely to be able to process all the calculation and the tool will fail.

Note that you can share your work/data by zipping the mydata folder, that contains a Nile folder (contains your data of the folder of your current database) and nile.sqlight (database management file). On a new computer you can extract the zip file and load it as an existing database.

## 3.2 Visualize already programmed suitability and feasibility maps

If you have unzipped the Nile data into to Nile folder then the tool is pre-loaded with several practices, namely apple, mango, multipurpose tree (example, Sesbania), different types of bunds, different types of terraces, irrigation from the river, gullies and  grazing land management.

For visualizing a map, select the practice and click view practice map



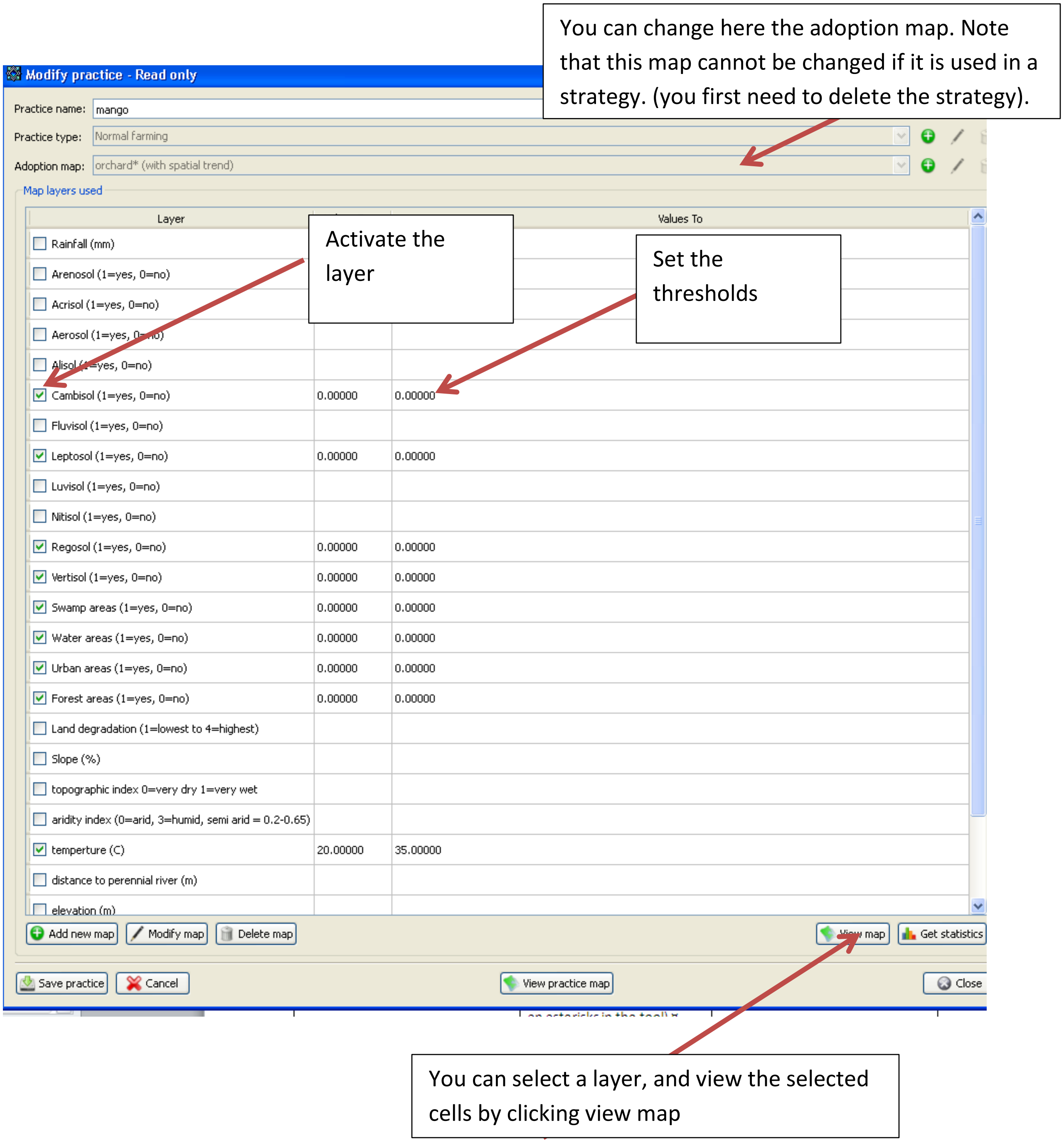

If you want to modify the settings of the selected practice, click "modify" and select the layers you want to add and or adjust the thresholds, and/or change the adoption map.

For binary layers, such as for example water area, choosing threshold 1 will select all the lakes in the area (i.e. Lake Tana), choosing the threshold 0 will select all areas that are not lakes (i.e. the Nile Basin without Lake Tana).

There is only a limited number of adoption maps made available with this version of the tool, but several practices can use the same adoption map (see Table below). Two different models have been used to create these adoption maps: one with and one without spatial trend. Both resulting maps can be used. However, model comparison has been performed and the tool indicates -with an asterisks- which of the two maps performs better.

| Adoption map | Better model (indicated with an asterisks in the tool) | Can be used with practice |
|---|---|---|
| Orchard | With spatial trend | Mango, apple, coffee, papaya |
| Multipurpose tree | Without spatial trend | All type of multipurpose trees |
| Soil and water conservation | With spatial trend | Terraces, bunds, gullies, … |
| Irrigation from the river | Without spatial trend | Irrigation from the river |
| Wells | With spatial trend | Wells |
| Water harvesting | Without spatial trend | Water harvesting, ponds, cisterns |
| None | | Others |

**Suitability and feasibility maps cannot be changed, if the practice has already been used in a strategy (i.e. in a combination). If you want to change parameters you first need go into the strategy too (see section 3.4) and delete the strategy.**




By choosing a threshold for a particular layer, you constrain the model of suitable areas. To see these single constraint maps, i.e. see the cells that are selected, select the layer and click view map.

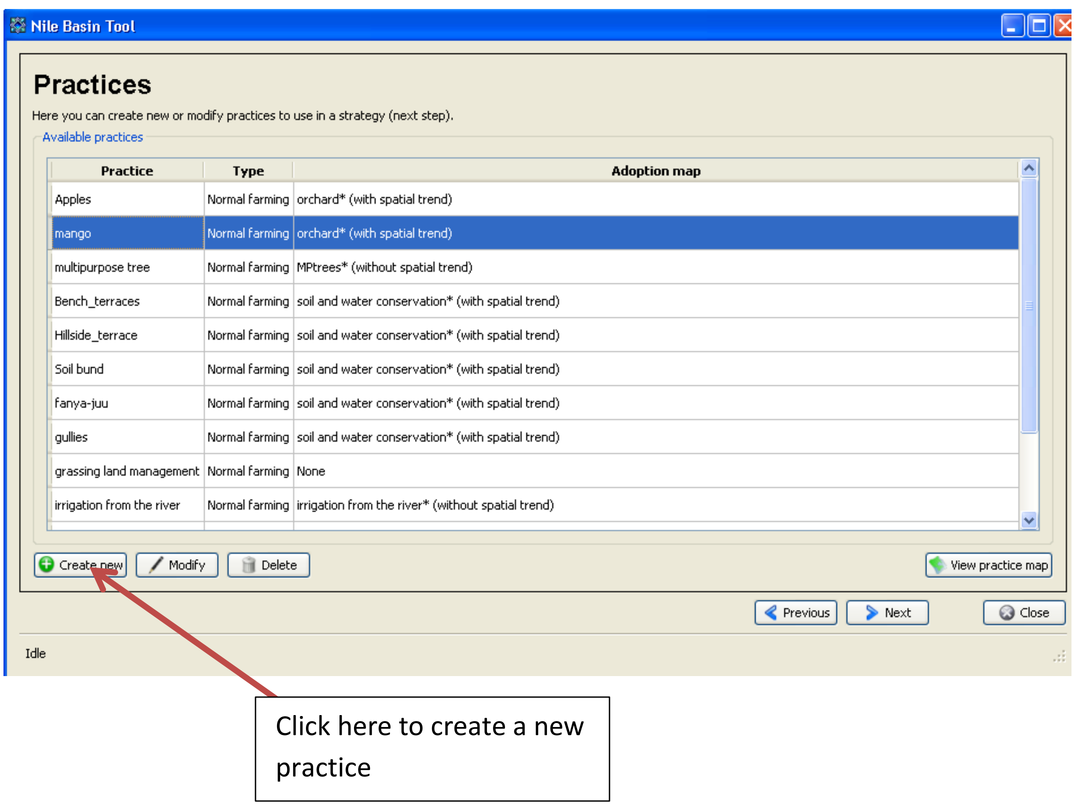
The map opens into a new window. In this window you can zoom into your layer and save your map as an image.

*Exercise 1*

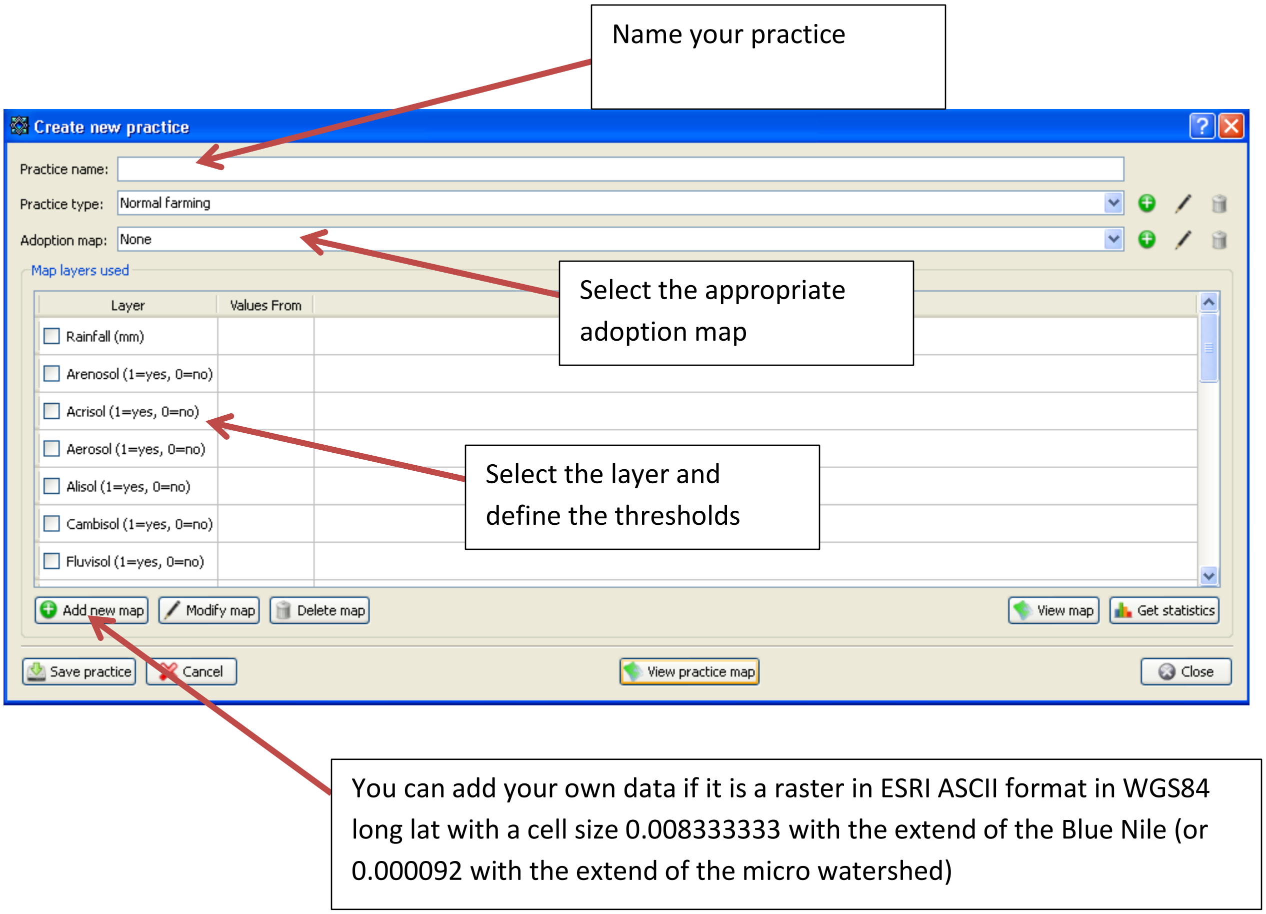
- *Map irrigation from the river, does the map makes sense to you?*
- *Set the distance to the river <1 km, does this map make more sense?*
- *Save your new map*
- *Map the feasibility of bunds; can you also map the suitability? Can you view the map that is constrained by slope only?*
- *For mango, change adoption map to orchards without spatial trend. What happens?*

## 3.3 Create your own suitability and feasibility maps

You can create your own suitability and feasibility maps, by selecting the layers and defining the thresholds.

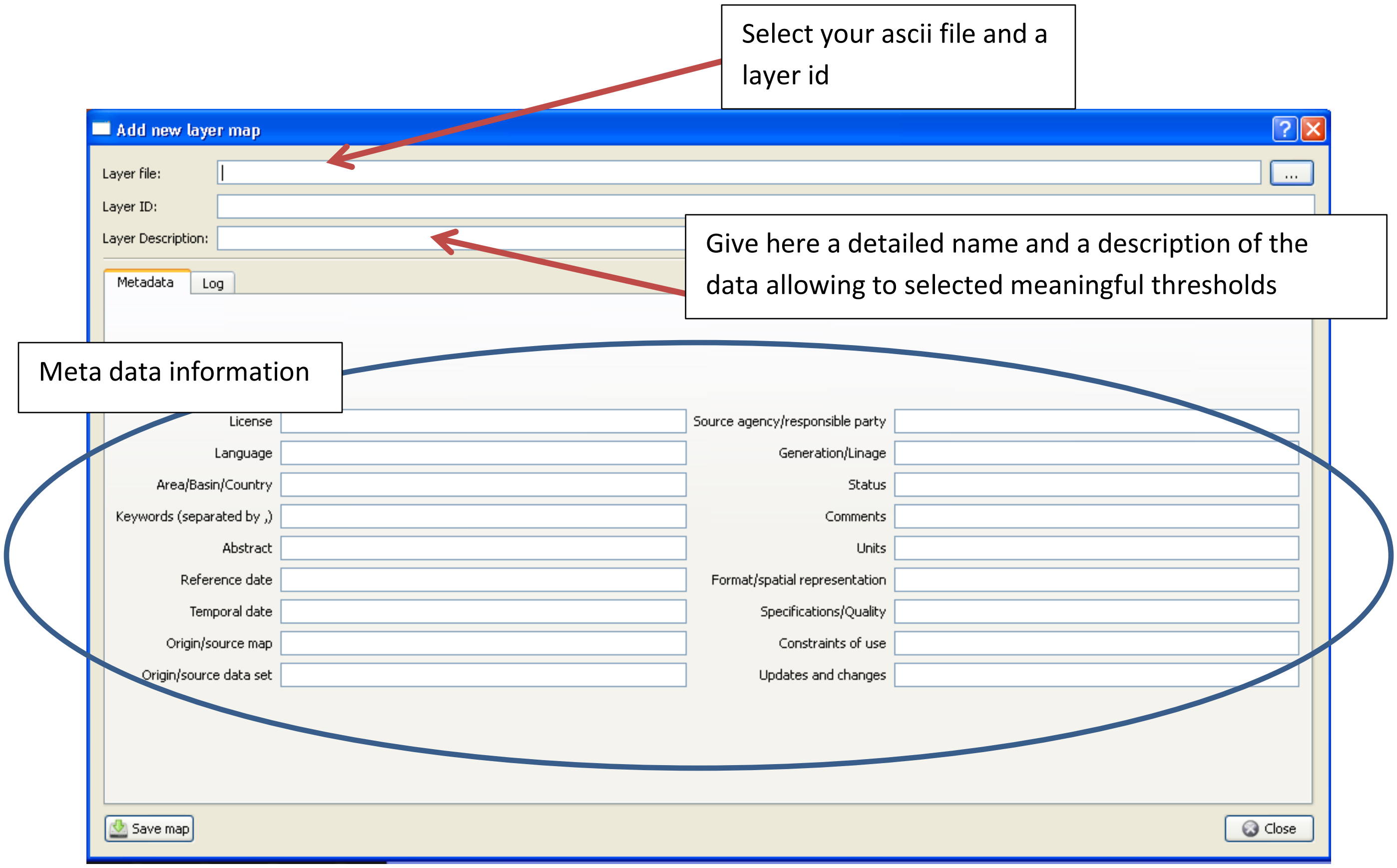



Click the "create new" button. You then get a similar screen as for existing practices where you can select layers/thresholds and adoption maps.




You can also add you own layers if your data is in ESRI ASCII format in WGS84 long lat, with a cell size of 0.008333333 and the extent of the Blue Nile. (for micro-watershed use cells size 0.00092 with the extend of a microwatershed). Section 4 shows you how to convert your own data into ESRII ASCII format with ArcGIS and Grass.

When you upload a new data layer, you get a window which asks about the metadata of your layer. It is important to fill all the blank spots so that other user know which data you have been using.




*Exercise 2*

*Create a suitability maps for hand dug wells*

- *What are the suitability criteria?*
- *Add shallow water ascii raster to the tool. This file contains values between 0-2, where 2= very shallow groundwater, 1= shallow groundwater, 0=deep and very deep ground water.*

*Create a feasibility maps for hand dug wells*

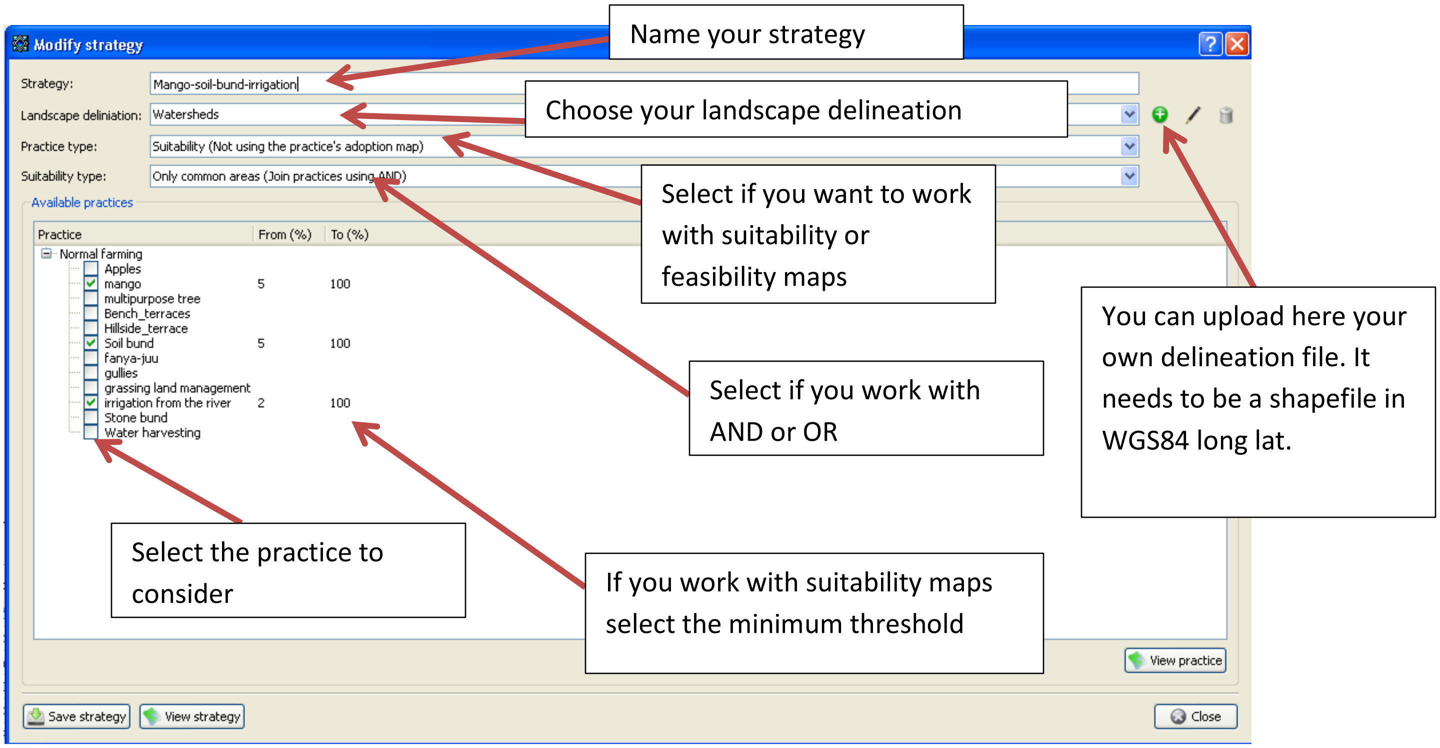
- *Which adoption map do you use?*
- *Are you satisfied with the maps you have created?*

## 3.4 Create your own strategy map

Once you have programmed all the practices you want to look at, you can start looking at combinations of practices. Click next to get onto the Strategy page.

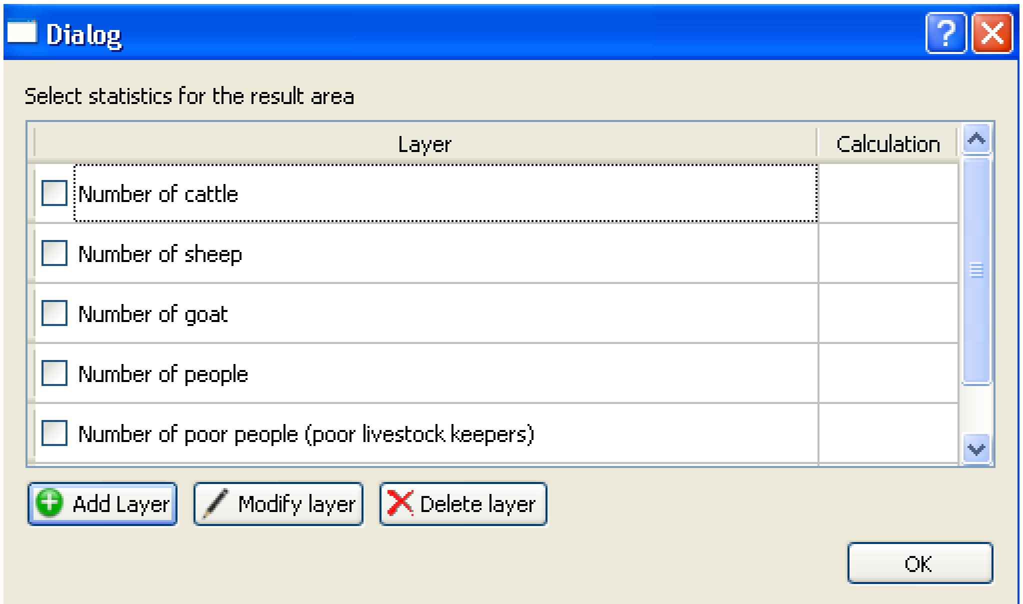
You can combine practices in two ways: with an AND or with OR. You use AND when you want to look at combination of practices that need to be implemented together, for example apple trees and wells. You use OR if you want to aggregate similar practices, for example if you want to aggregate soil bunds and stone bunds into bunds.

Secondly, you can make strategy map based on the suitability maps, in which case you need to define a minimum area that needs to be suitable. If you choose to combine based on the feasibility maps, the minimum adoption rate of all the practices within the strategy will automatically be chosen.




This tool uses the FAO Watershed delineation. You can add your own delineation by clicking + next to watersheds. It needs to be a shapefile in WGS84 long lat. **Note that if there are too many watersheds, the tool cannot process the computation anymore and the tool will return an error.** Save your strategy.

When you want to view the strategy, you can select some statistics about affected people or livestock. You can select which indicator you want to know more about.




The strategy map will show you the relevant watersheds as well as the corresponding statistics.

*Exercise 3*

*Look at the already programmed strategies.*

*Do they use AND or OR*

*Do they use suitability or feasibility?*

*Can you compute some statistics?*

*Create your own strategy*

# 4 Preparing your own data for the Nile Goblet tool

## 4.1 Format needed for the Nile Goblet tool

The Nile Goblet tool reads only ESRI ASCII grid files, also known as the AAIGrid format with the extension .asc. The layer needs to be in the geographical projection (i.e. longitude, latitude) in WGS 84 (also known as EPGS format 4326). For it to be compatible with the data already made available with the tool, the grid cell size has to be 0.008333333 degrees, which corresponds approximately to 1 km and the extent, or 0.000092 degrees for the 10 m extend.

The data you want to upload may however be in vector format (point, line or polygon) or be a raster file in different format than ASCII, such as raster grid, tiff, img etc… The datasets may also have a different projection than WGS84.

In the following sections you will be taken through the different techniques which help you to prepare your data for the Nile Goblet tool. Instructions are given for \ ArcGIS as well as Grass, an open source program.

## 4.2 Preparing data in ArcGIS

This section assumes that the reader has basic knowledge of Arc GIS, we recommend *GIS training for agricultural research centers,* as a reference manual in case the explanations would not be sufficient. For each topic in this section we refer to the exact section of this manual as follows (GIS ARC section number).

### 4.2.1 Check and rectify the projection of your data (GIS ARC 6.4)

There are spatial data that have no explicit projection defined for them (i.e., they have no .prj file telling the ArcGIS program what projection the layer is in) or are not in the projection necessary for the tool. It is therefore crucial to check and if necessary re-project the data.

To check you projection: *Open the layer in ArcGIS – right click – properties*

There are three options:

- The data is in the correct format, namely WGS84 longitude latitude (GCS_WGS_1984)
- The data has a different projection, for example WGS84 UTM37 and needs to be projected.
- The data has no defined projection, the projection needs to be identified and the data re-projected.

If your data is projection in the wrong projection, you need to reproject it :

The project tool works both from the Arc Catalog and the Arc Map interface. Use one interface but do not have the file open in both. You can find the tool in Arc toolbox.

**For feature dataset/ Shapefiles**

*Arc Toolbox → Data Management Tools →Projections and Transformations → Feature → Project*

**For Raster dataset**

*Arc Toolbox → Data Management Tools →Projections and Transformations → Raster →Project Raster*

Both for raster and feature, *choose : select from a predefined coordinate system, geographic, world, WGS84*

Note that if you data is in a Adindan, you also need to indicated a transformation from Adindan to WGS. For Ethiopia choose transformation number 4.

If your data has no defined projection you need to figure out the original projection. You can do this by comparing the extent of the dataset with an extent of another dataset which you know the projection or by guessing the possible projections in that area. Often Ethiopian data is in WGS84 long lat, WGS84 UTM37 or Adindan. Once you know in which projection it is you can use the define projection tool :

*Arc Toolbox → Data Management Tools →Projections and Transformations → Define Projection*

### 4.2.2 Rasterize shapefile/vector data (GIS ARC 7.2.3.1)

You may have vector datasets which you want to include as suitability criteria in the Nile Basin tool. In this case you have to convert the vector to raster format. For this Nile Goblet tool, do not forget to assign a valid cell size 0.008333333 and extent of the Blue Nile in the conversion process. You can find the tool in Arc Toolbox

*Arc Toolbox →Conversion Tools → To Raster → Polygone to Raster OR Feature to Raster*

### 4.2.3 Reclassify rasters (GIS ARC 7.2.3.2)

Reclassification is important when you want to replace old values with new values. For example, you have a land use raster and the land use type has changed through time. To represent the current land use situation, you want to change the old land use type to the new one. So you assign the new value (new land use type) in the 'new value' field to all the cells which represent the old land use type. You can find the tool in Arc Toolbox.

*Arc Toolbox →Spatial Analyst Tools →Reclass →Reclassify*

### 4.2.4 Resample raster

If you get a raster that doesn't have the right cell size (namely 0.008333333/0.000092) you need to resample the raster

*Arc Toolbox → Data Management tools →Raster → Raster Processing →Resample*

### 4.2.5 Interpolation (GIS ARC 7.2.5)

Sometimes you may have point data from GPS readings or from weather stations and you want to use them in the Nile Goblet tool. You can create a raster layer from point data using different spatial interpolation techniques. Spatial interpolation is used to estimate a value of a variable at an un-sampled location from measurements made at other sites. You can find the tool in Arc Toolbox.

*Arc Toolbox → Spatial Analyst Tools → Interpolation*

The most common interpolation techniques that are available in ArcGIS are the following :

**IDW**

The IDW (Inverse Distance Weighted) tool uses a method of interpolation that estimates cell values by averaging the values of sample data points in the neighborhood of each processing cell. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process.

**Kriging**

Kriging is an advanced geo-statistical procedure that generates an estimated surface from a scattered set of points. It takes spatial correlation between the different points into account.

**Natural neighbor**

Natural Neighbor interpolation finds the closest subset of input samples to a query point and applies weights to them based on proportionate areas to interpolate a value.

**Spline**

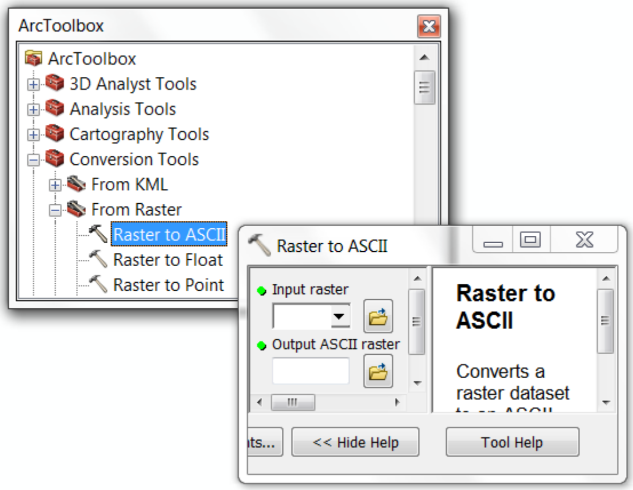
The Spline tool uses an interpolation method that estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points.

### 4.2.6 Convert to ASCII file

An ASCII file is a text file representing raster data. It is defined by the number of colums and rows.

This is the format need for the Nile-Goblet tool. To transform your raster data in ascii

*Arc Toolbox →Conversion tools → From Raster → Raster to ASCII*

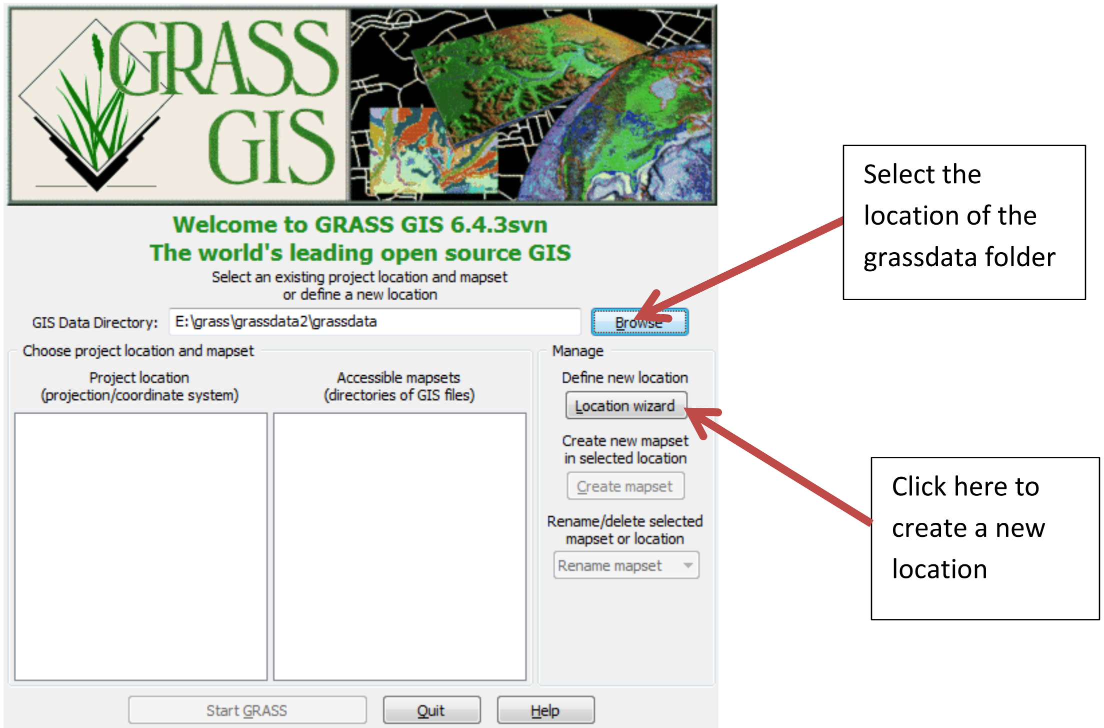



## 4.3 Preparing the data in Grass (open source solution)

Grass is an open source (and therefore for free) GIS software package. It is one of the only open source software packages that can call on Gdal, a code that allows to transform grids and vector data into different formats with a graphical user interface. You can download the software on http://grass.osgeo.org/download/index.php

### 4.3.1 Define the data folder

In order to work with Grass, you need to keep all the geographical data in one folder, usually Grass users create a grassdata folder. When you start Grass with the graphical user interface (select Grass GUI in the program start), the window below appears. Indicate where the data folder is located.



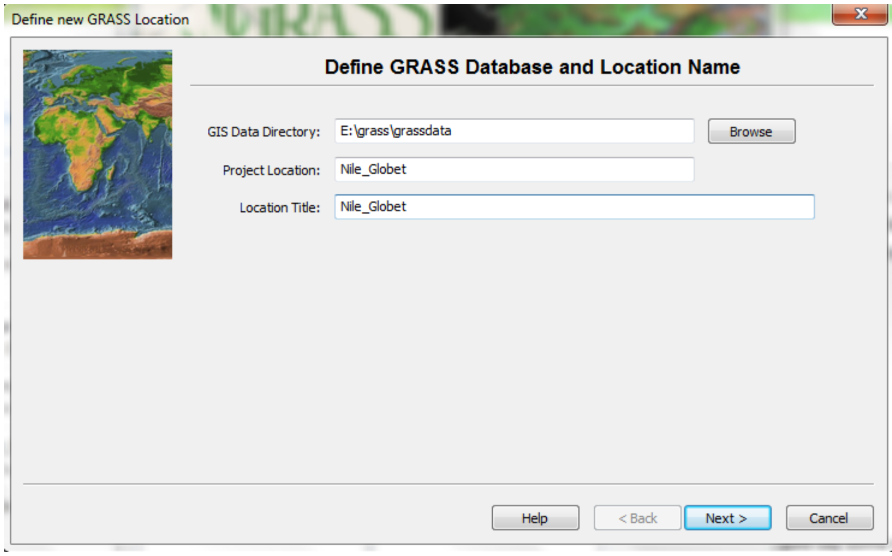

### 4.3.2 Create a location and mapset

Unlike ArcGIS, Grass works with the “database logics”, this means you need to create a so-called location, which defines the extent, the projection and the grid size on the workspace you are going to work on. In other terms, a location is some geographic extent of interest that contains data sets that must all be in the same coordinate system. Every location has a PERMANENT directory which stores some basic information about the whole location, and is a good place to park base files. You can think of a location as a data library for a region of interest.

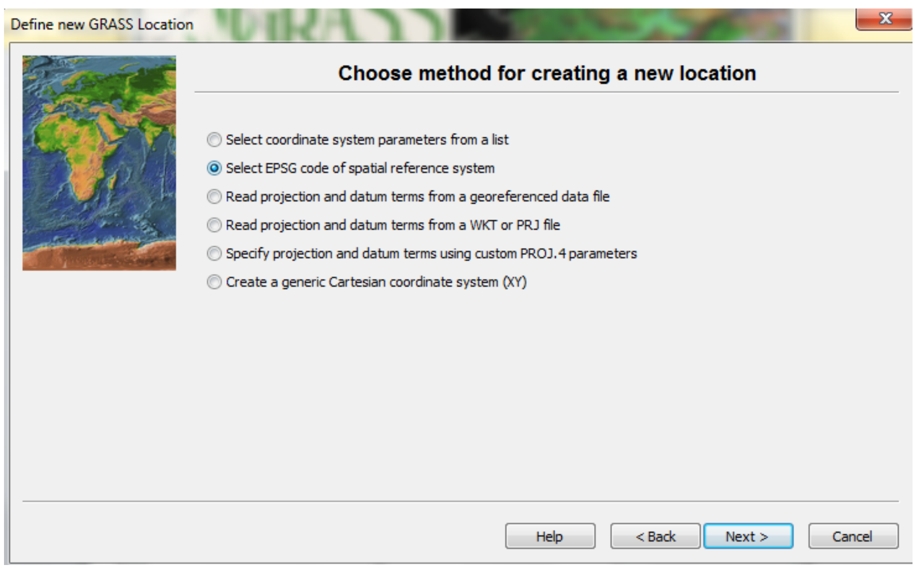
In a MAPSET you can organize GIS maps thematically or geographically or by project or whatever. Every GRASS session runs under the name of a MAPSET. A MAPSET may be a geographical subset or as large as the parent LOCATION. Technically they are subdirectories under any location. In this manual, we work only with the PERMANENT mapset.

Once the location is fixed, all the data you will import will automatically be converted to the format that has been fixed in the location. Note, only data with the same projection than the location can be loaded into this given location.

Once you have indicated the data folder you can click on location wizard to create a new location. In the first set the name of the new location. Experienced Grass users suggest to indicate the projection in the name of the location.



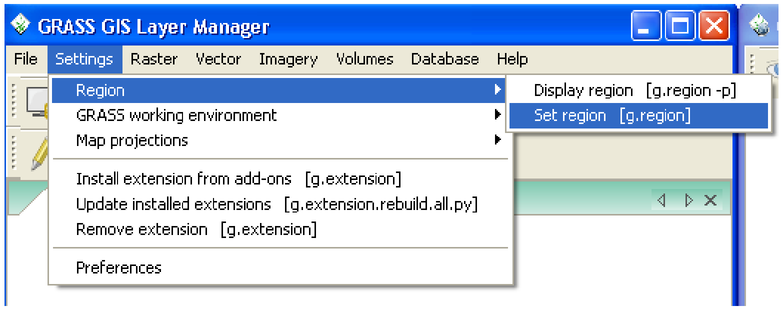

In the second step, you need to define the projection. Choose select EPGS code. Then select the code 4326[2] which corresponds to WGS84. If you have a layer that is in WGS84, you can also use "read projection and datum terms from a WKT or PRJ file" by selecting the PRJ file for the given layer.




You need to set a region for your location that is defining the extent and the resolution you want to work with. Grass will ask you automatically if you want to set the region, and you can enter the settings manually.

The better option is to cancel the automatic option and set the region, once the GUI is open under setting – region – set region.

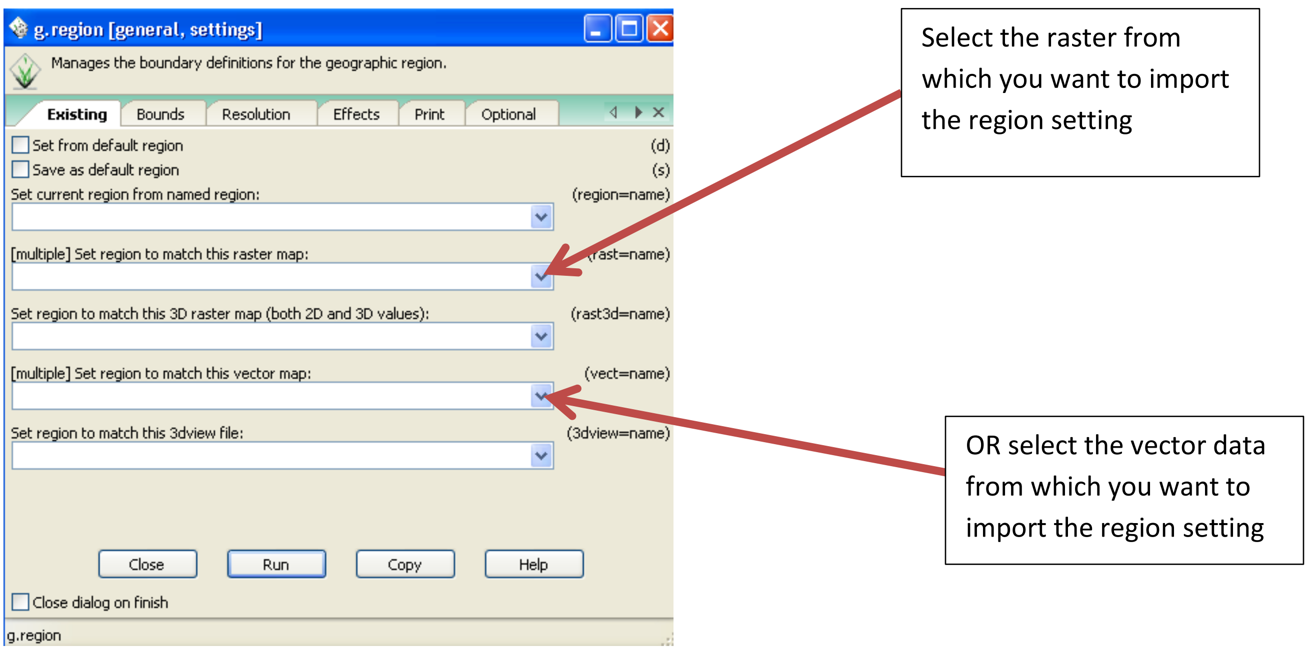
[2] http://www.geometryit.com/igis/?p=85 allows you to identify the EPGS code based on an esri .prj file




You can enter manually the settings for the Blue Nile Basin and the Nile-Goblet which are:

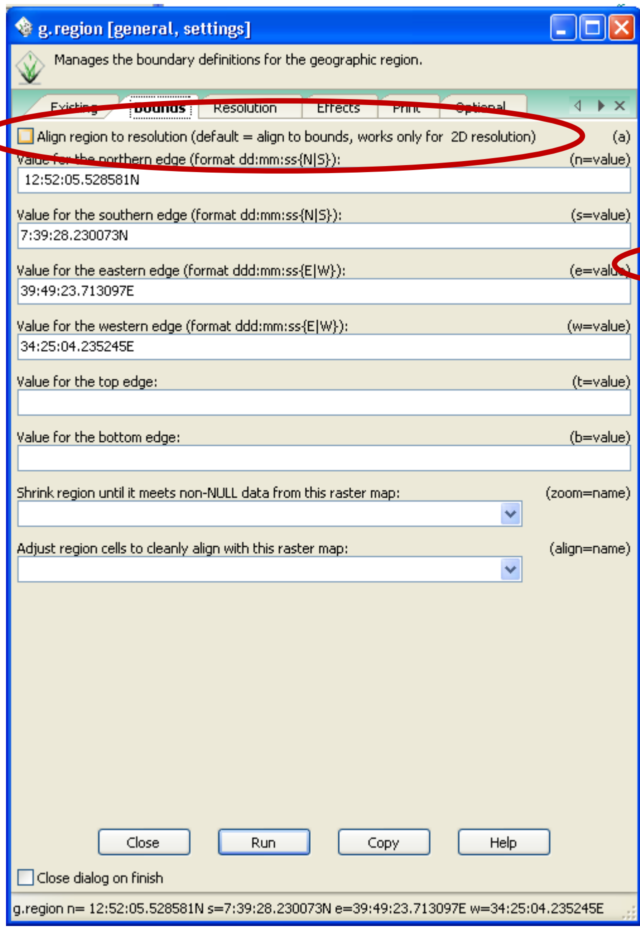
Under bounds : north: 12:52:05.528581N  
south: 7:39:28.230073N  
west: 34:25:04.235245E  
east: 39:49:23.713097E

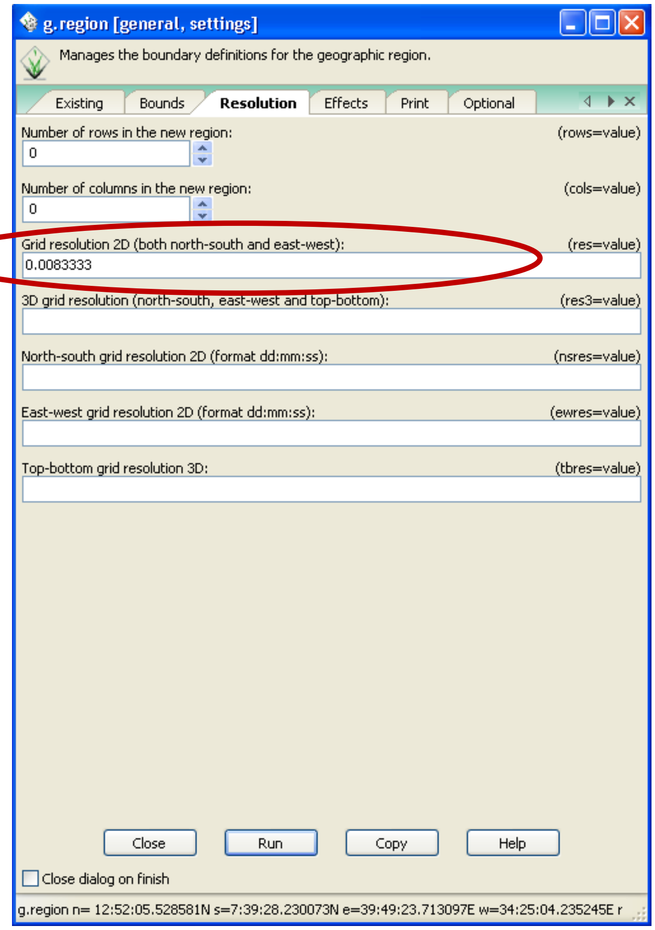
or you can make use of a raster or vector layer with the right projection, extend and resolution.




In order to make sure that you have the right cell size to fit the Nile-Goblet tool you need additionally to

- select Align region to resolution (under bounds)
- set cell size resolution 0.008333333 (under resolution) (or 0.000092 for micro watersheds)

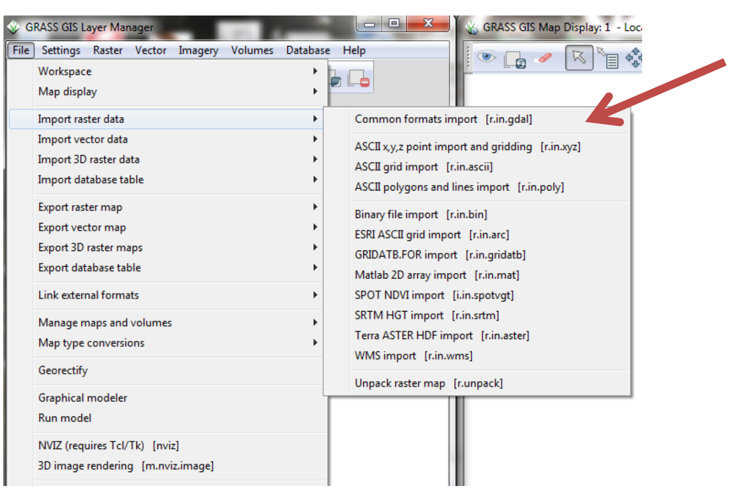


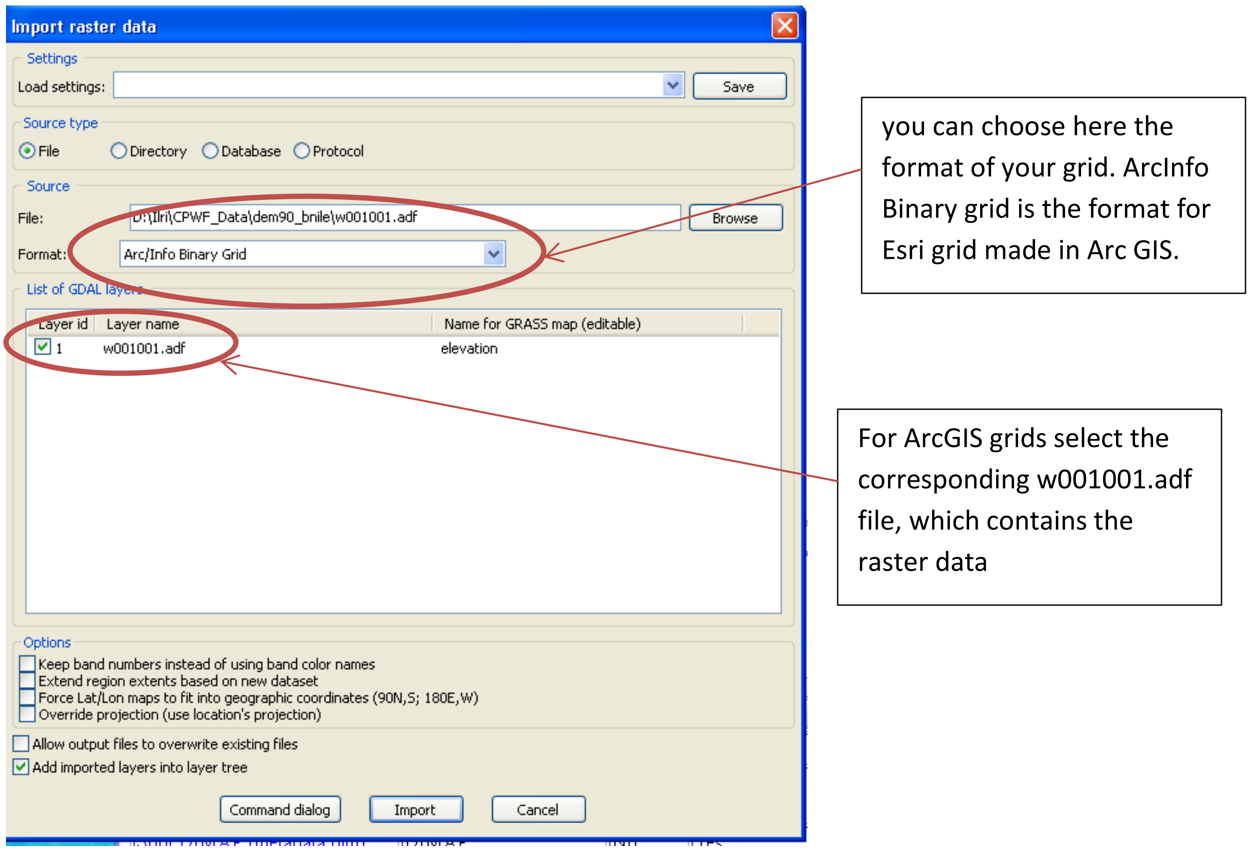

Now you location is ready. When you import data, then all the layer are automatically in with the pre-defined cell size : no need for resample.

### 4.3.3 Import and convert data

Open source software call on the so-called GDAL code to convert geographical layers in different formats. A list of format handled by GDAL is very broad, includes all ESRI/ArcGIS format. A full list can be found under : http://www.gdal.org/formats_list.html

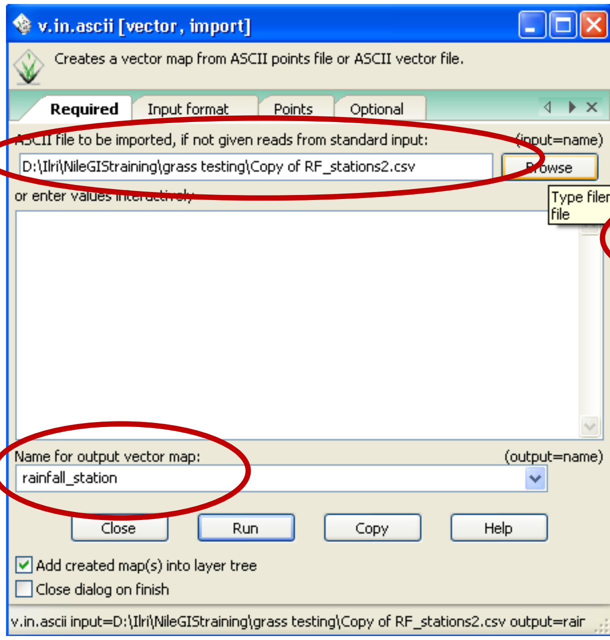


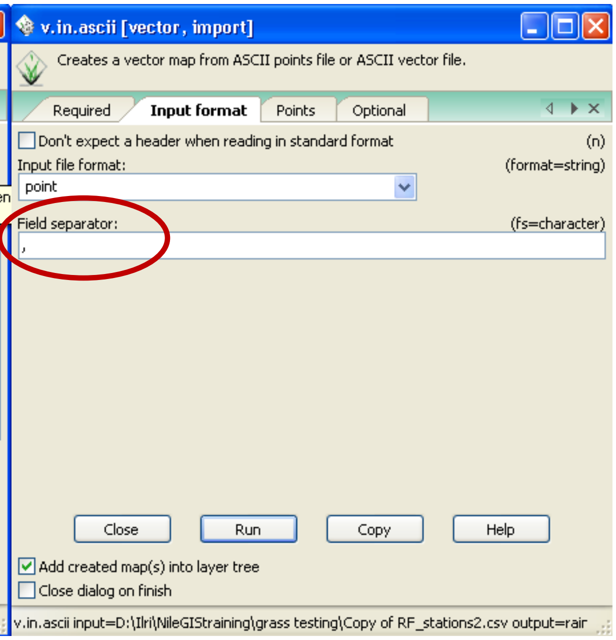
A simple interface allows to import ESRI raster and ESRI shapefiles. Whereas shapefiles can be easily recognized and selected from the list, raster are more complicated. Indeed, ESRI GRID rasters are stored in folders which contain one Info subdirectory and a subdirectory for each GRID. Each GRID subdirectory contains several files that store geographic location and the actual raster data for the corresponding grid. A grid layer usually contains the a whole range of files, the file "w001001.adf" contains the actual raster data. This is the file that need to be imported.



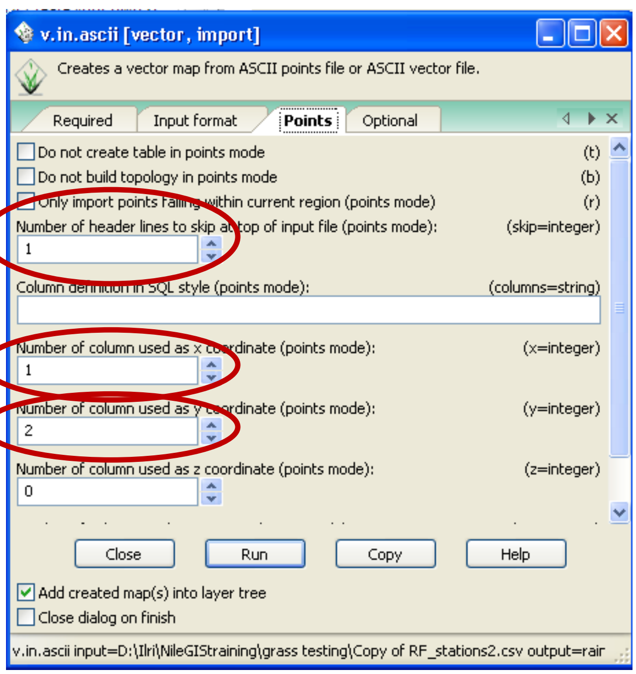

If you want to import point data from an excel file (for example form GPS data), convert your file into CVS comma delimited. The coordinates should be in decimal degrees.

Then use the : File – import vector data – ASCII file (v.in.ascii).
Under required select the your CVS file and give a name to your output file.
Under input change field separator ","




Under points indictate that the first line should be skipped, the collum of the x and y coordinates, and click run. Your data is imported automatically.




### 4.3.4 Project or re-project data

As a first step, you need to check the projection of the layer you want to use. Raster and shapefiles coming from ArcGIS always consists of several files. The file finishing with .prj contains the projection

and datum of the layer. You can right click on this file and open with the note pad to learn about the projection of the layer. If it is not WGS84 you will need to re-project the data.

Remember Grass works with locations which define the projection, extent and resolution of the data. If data is in different projections, then a location for each projection needs to be created and the respective data imported into the location. As you have the projection file, the easiest way is to create a location with "read projection and datum terms from a WKT or PRJ file" (see chapter 4.3.2). If no projection is defined (no prj file), you can open the map in a generic Cartesian XY system to analyze the extent.

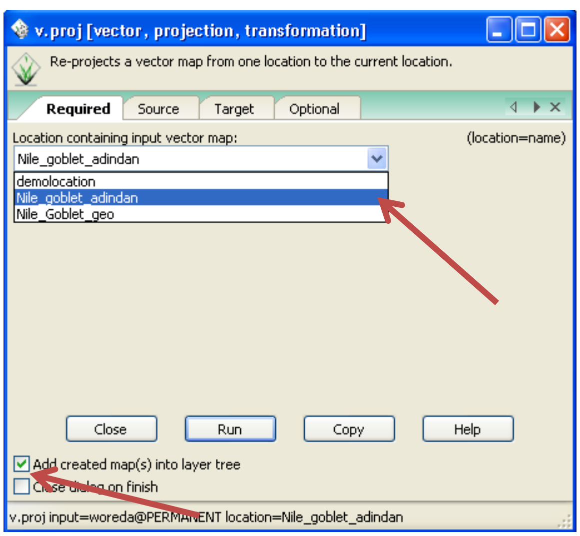
To re-project data, open the location with the projection and datum you want to reproject the map in, for Nile Goblet this is the location in WGS84 or EPGS 4326.

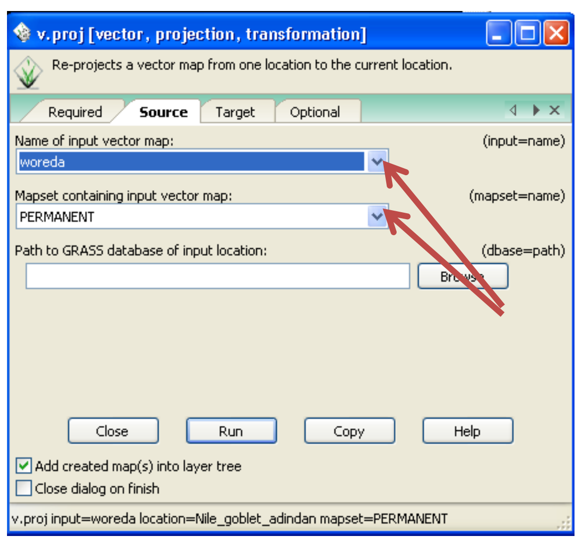
Then use re-project under

- raster – develop raster map – reproject raster
- vector –develop vector map –reproject vector

Depending on the format of the layer you want to reproject

To re-project you need to indicate in which location the layer you want to re-project is under required, also click "add created maps into layer tree. Under Source indicate the mapset (if you have not create any mapset it will be in permanent) and the layer you want to re-project. The click run.



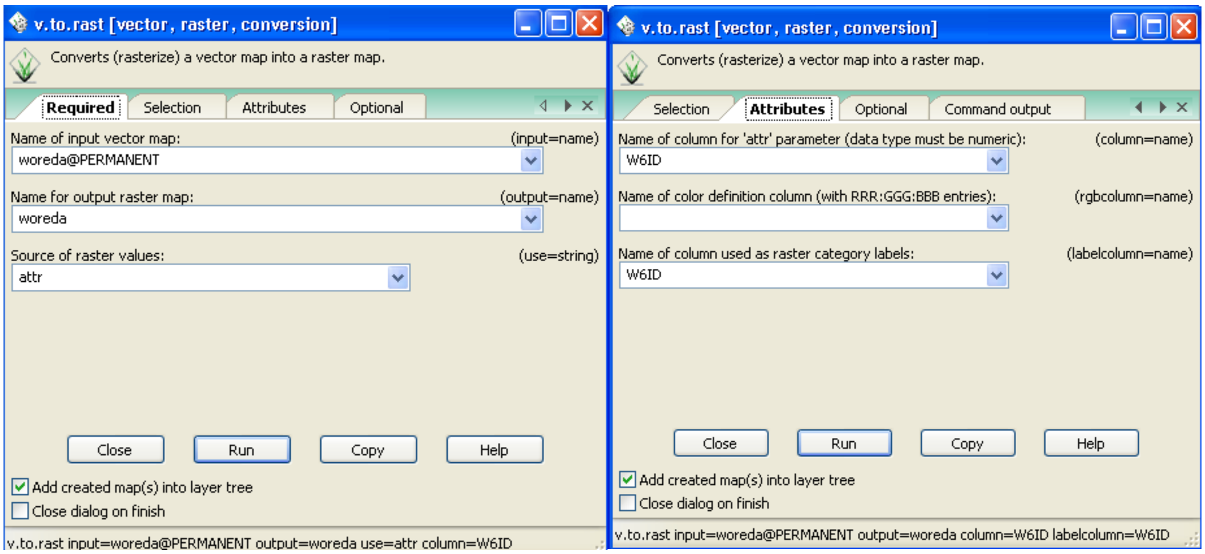




### 4.3.5 Rasterize shapefiles

Rasterize shapefile or vectorize raster can be done with the command found under :

- Raster – map type conversion – raster to vectors
- Vector – map type conversion –vector to raster

Under require you can indicate which map needs to converted, and under Attribute, which attributes needs to be converted. Note that the conversion from raster to vector or vector to raster only works when the fields are numeric.




If you do a vector to raster, then the cells size will be the one set in the location.

### 4.3.6 Reclassify rasters

Grass has a reclassify tool under raster – change category and values-reclassify.

In fact, the reclassify tool does not generate any new raster map layers (in the interests of disk space conservation). Instead, a reclass table is stored which will be used to reclassify the original raster map layer each time the new (reclassed) map name is requested. As far as the user is concerned, that raster map has been created.

The reclass tool only works on an integer input raster map; if the input map is instead floating point data, you must multiply the input data by some factor to achieve whole number input data, otherwise reclass tool will round the raster values down to the next integer.

You can use the map calculator (under raster), under can be used to convert a reclass map to a regular raster map layer as well: r.mapcalc "raster_map = reclass_map" where raster_map is the name to be given to the new raster map, and reclass_map is an existing reclass map.

Category values which are not explicitly reclassified to a new value by the user will be reclassified to NULL.

### 4.3.7 Interpolation

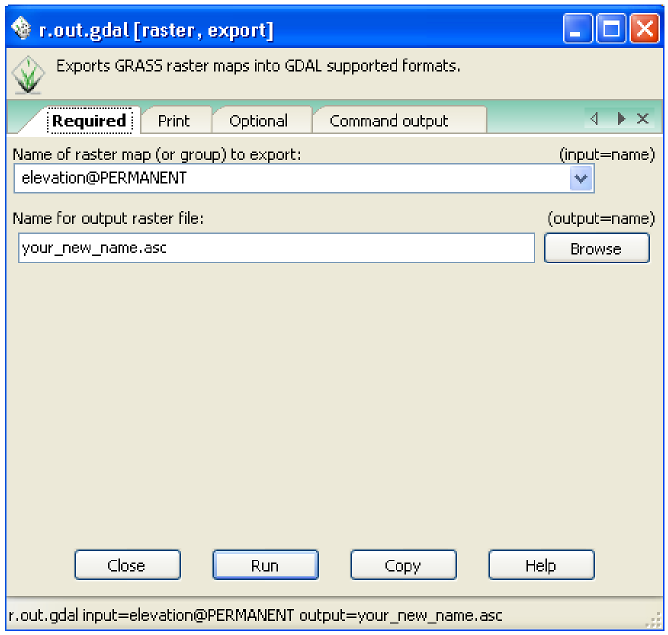
In Grass, interpolation within the GUI is much less developed than in Arc GIS. Indeed, Grass user usually call upon the open source program R to compute the spatial analysis. Only inverse distance is available in the GUI, *under raster – interpolate – IDW from vector points.*

Kriging, can be called as an add-on in Grass 4 (it will be automatically available for all version above 6.5). You can install the add on under : setting – install extensions from add-on – select v.krige from the list under vector.

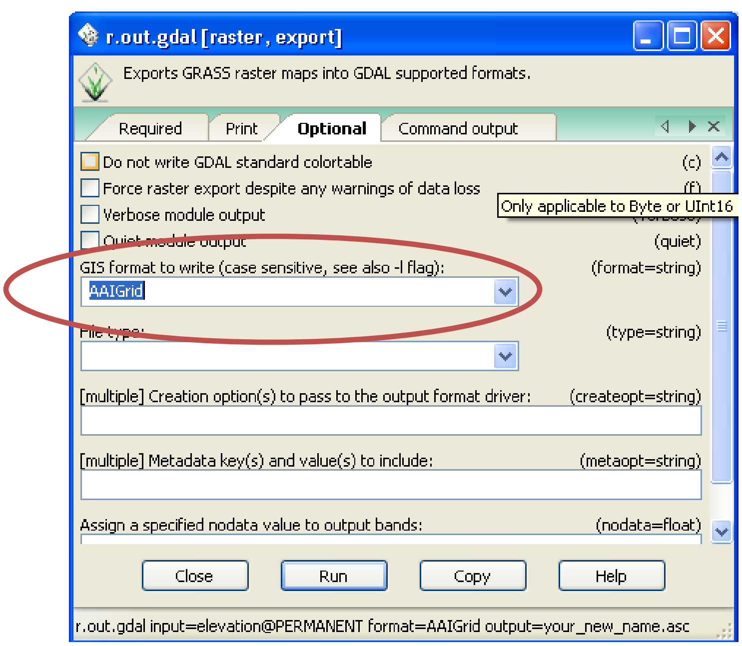
### 4.3.8 Convert to ASCII file

To convert a raster to ascii format, go to file-export raster map – common export format

Give a new name to your ascii file and the extension asc : "your_map_name.asc" under required




And select the AAI format under optional



# 5 Exercises for preparing your own data for the Nile-Goblet tool

## 5.1 Prepare polygon layer for Nile-Goblet tool

The objective of this exercise is to create soil maps for the Nile Goblet tool, based on the soil shapefile.

*Exercise 4.1*

- Check the projection of the layer 'soil_abay_bain.shp'. ( Folder Soil_1)What do you observe?
- Check the extent of the layer and make the data/layer in UTM projected coordinate system with datum WGS84. You see an additional file when you open the data in windows explorer. What does this file indicate?
- Change the projection to geographic coordinate system without changing the datum.
- Rasterize the soil layer with appropriate cell value
- Reclassify the soil layer in to vertisol and non vertisol
- Make the appropriate raster format to Nile Goblet tool

## 5.2 Prepare point layer for Nile-Goblet tool

The objective of this exercise is to create a rainfall map based on data from meteorological stations.

*Exercise 4.2*

- Create a point data from the excel file '**RF_stations.xls'**
    - for Arc GIS refer to sec 9.12.1 of previous manual
    - for Grass user, save your excel sheet as CVS format, comma delimited before importing it as ASCII file
- Interpolate the rainfall point data using IDW and kriging. The field field to 'ANNUAL' represents the annual rainfall. Compare the outputs.
- For ArcGIS user (skip if you use Grass) Overlay the interpolated raster with the basin boundary layer. What do you observe? How do you correct it?
- Create a layer in format that suits the Nile Goblet tool

# 6 Discussion of the exercises

## 6.1 Exercise 1

Exercise 1 is straight forward and applies the manipulation explained in the precedent section. If you have used the original data, you will not be able to change the adoption map of mango, because it is used in an already programmed strategy.

## 6.2 Exercise 2

For hand dug wells, one suitability criteria is the availability of shallow and very shallow groundwater. This layer has not yet been introduced in the tool and therefore needs to be loaded. If you have experience in the Ethiopian highlands, then you will think that the suitability map based on the groundwater map must be wrong. This map is based on the geological subtract and is not very accurate. Nonetheless it is the groundwater map that is currently available for Ethiopia. This should remind us that the suitability map can only be as good as the input maps we have used.

Furthermore, when you overlay the adoption map, all area that is suitable for wells have no adoption. Again part of this result is that the groundwater input map does not constrain the suitability very well. In addition, the adoption maps suggest that very few locations meet the socio-economic feasibility criteria. Finally, the adoption maps have been created based on a farm household survey, in which only about 5% of the farmers had a well. This might distort the results.

The aim of this exercise is to show you that uncertainty linked to the suitability and feasibility maps can be quite high.

## 6.3 Exercise 3

This exercise aims at familiarizing you with the different aggregation options with AND or OR and with suitability and feasibility maps.

## 6.4 Exercise for preparing your own data for the Nile-Goblet tool

### 6.4.1 Exercise 4.1 : Polygons

1. You are given a soil map, in a shapefile format with no defined projection. You need to figure out the projection first by loading the data, looking at coordinates and extent.

   *In Arc : load your data, right click on the layer and look at properties*
   *In Grass : load the data into a generic location*

2. If you have experience, you will discover that coordinates are not in decimal degrees and the extent corresponds to WGS84 projected in UTM37. So you need to assign this projection to your data

   *In Arc : use the define projection tool box (predefined coordinate system, projected, UTM, WGS84, Northern Hemisphere, zone 37N)*

*After setting the projection, if you open the file in windows explorer, you will see an additional .prj file which indicates the projection type.*
*In Grass : create a location with WGS84 projected UTM37 location (EPGS 32637)and load the data into this new location*

3. But you need your data in WGS84 long lat

   *In Arc : use the project shapefile tool (predefined coordinate system, geographic, world, WGS84).*
   *In Grass : create a new location in WGS84 (EPGS 4326) and use the project shapefile tool calling it from your WGS84 UTM37 location. Set the region making sure that you enforce the 0.008333333 cells size.*

4. Rasterize your data
   *In Arc: use the feature to raster tool and use the field 'MAJORSOIL', don't forget to set cell size 0.008333333*
   *In Grass : use the vector to raster tool, if you have specified your region correctly, you automatically have the right cell size*
5. Reclassify your data into 1 for a given soil type (for example vertisol (i.e Eutric vertisols & Calcic vertisols) and zero for the rest
   *In Arc use : reclassify tool*
   *In grass use the reclass tool to reclassify and use the mapcalc to create a new data layer that represents the reclassified data*
6. Transform to ascii file
   In Arc : use raster to ascii
   In Grass : use r.out.gdal, use AAIgrid, and don't forget to add the extension .asc at the end of your file name
7. Your layer is ready for the Nile-Goblet Tool

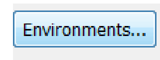
### 6.4.2 Exercises 4.2 : Points

You got meteorological station data that you need to interpolation. For rainfall the simplest and most wildly accepted method is inverse distance weighting, and the most used one is kriging. You can obviously use other methods and compare the different maps.

1. Check the projection and make sure that your data is in WGS84, apply similar correction that in the previous exercise if necessary
2. For inverse distance weighting use about 5-7 points corresponding to 10-15% of the points. By choosing a number that is too low (<4) you will have very abrupt transition between the different point (too much short distance variation), if you use too many points you are going to similar values for the whole basin (not enough short distance variation).
3. For Kriging, use 5-7 points and an exponential variogram.

For ArcGIS users, when you overlay the interpolated rainfall layer with the basin boundary layer, the interpolation does not cover the whole basin. In such cases, first, you have to set the processing extent

to the basin boundary extent in the environment settings. (click the Environments tab from the Kriging window)




In Arc: use inverse distance weighting tool or kriging under interpolation, and don't forget to set cell size 0.00833333.

In Grass : you can perform only inverse distance weighting in the GUI or kriging (if you  if you use Grass 7). For other interpolation techniques you need link Grass with R.